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UNIVERSITÄT FREIBURG

Algorithms for Radio Networks

MACAW

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MACAW

► Bharghavan, Demers, Shenker, Zhang

- MACAW: A Media Access Protocol for Wireless LAN's, SIGCOMM 1994
- Palo Alto Research Center, Xerox

► Aim

- Redesign of MACA
- Improved backoff
- Fairer bandwidth sharing using *Streams*
- Higher efficiency
 - by 4- and 5-Handshake

Acknowledgment in the Data Link Layer

► **MACA**

- does not use Acks
- initiated by Transport Layer
- very inefficient

► **How can MACA use Acks?**

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4 Handshake

► Participants

- Sender sends RTS
- Receiver answers with CTS
- Sender sends data packet
- Receiver acknowledges (ACK)

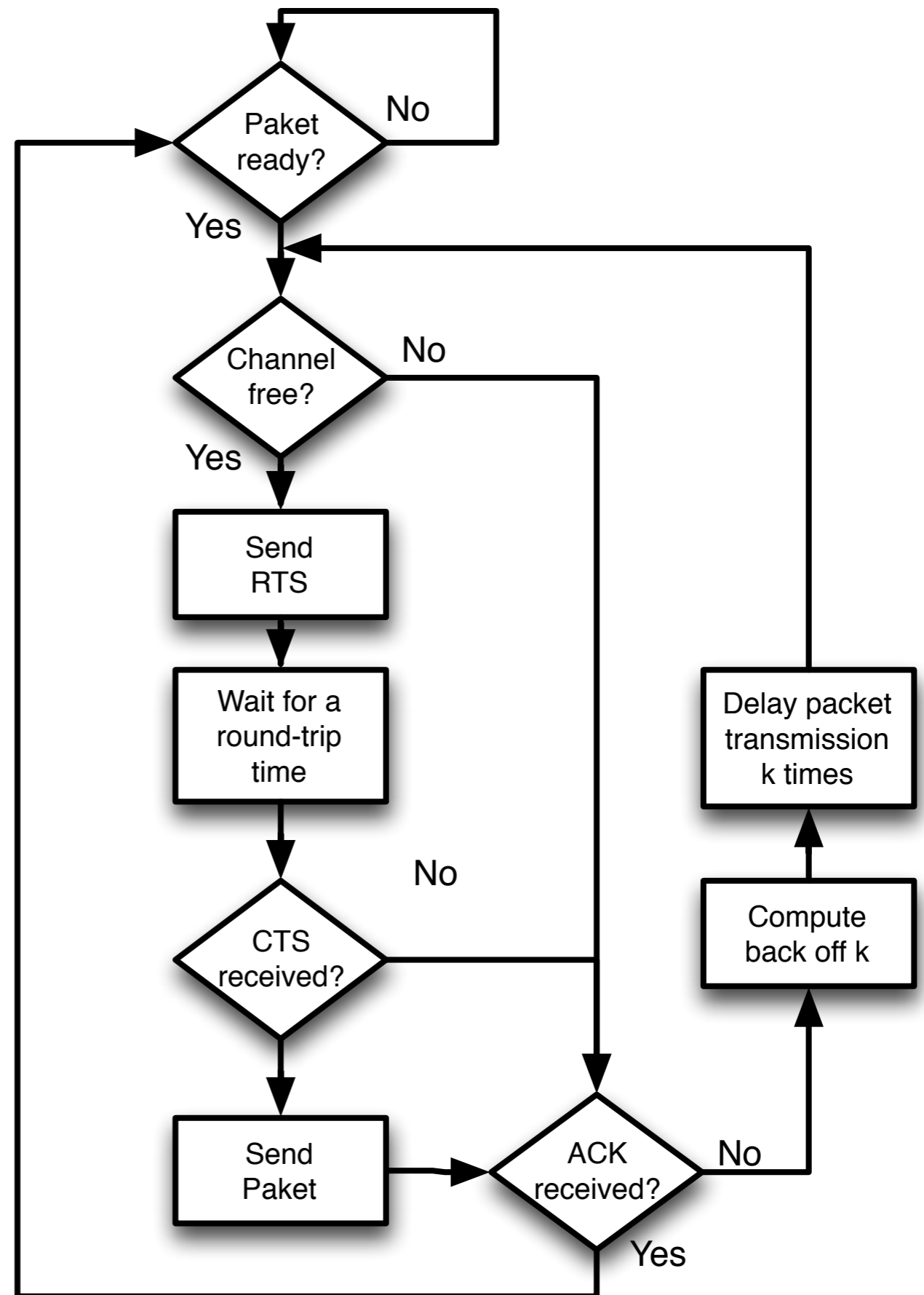
► Third parties

- Nodes receiving RTS or CTS are blocked for some time
- RTS and CTS describe the transmission duration

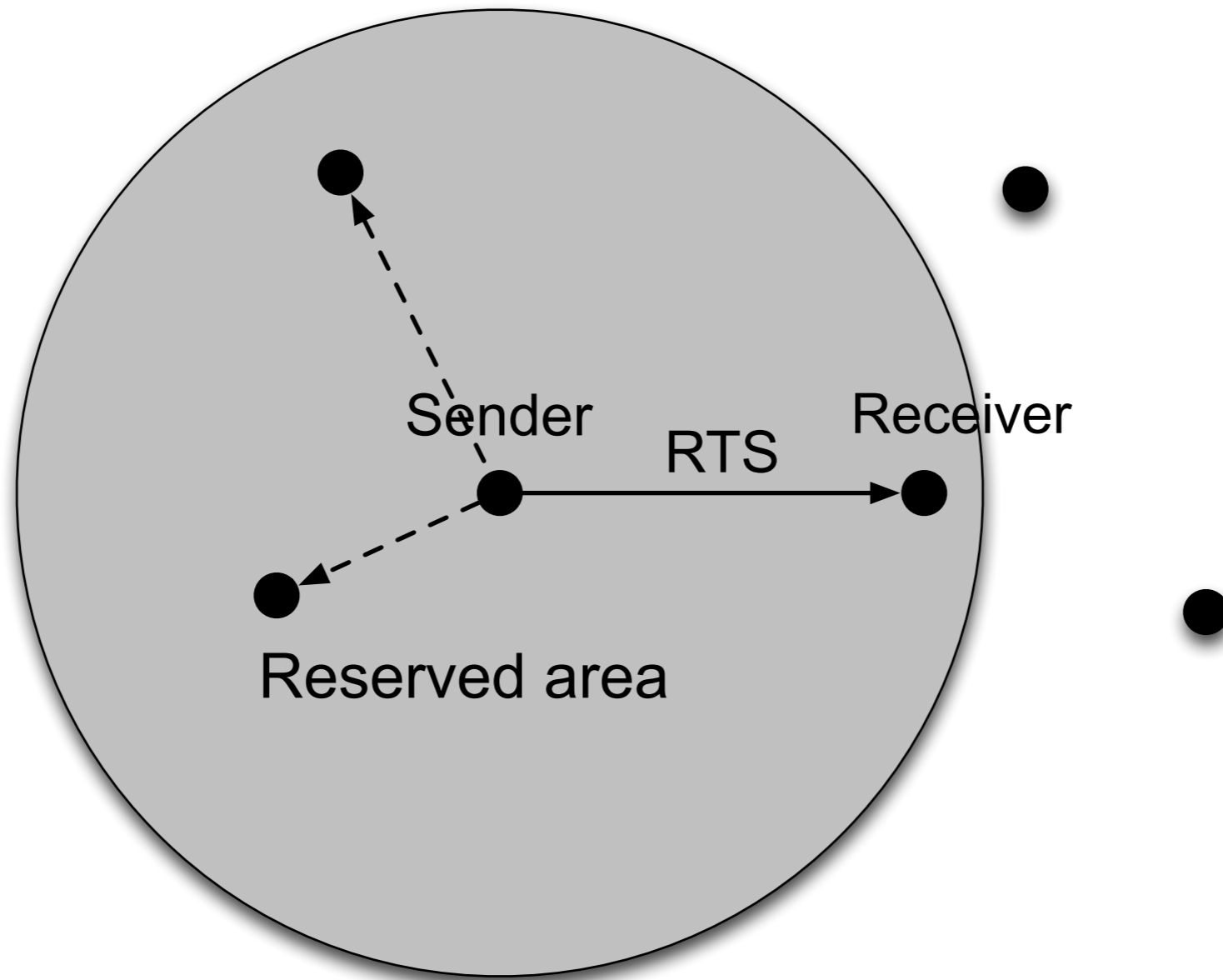
► **Sender repeats RTS, if no ACK has been received**

- If receiver has sent ACK
- then the receiver sends (instead of CTS) another ACK

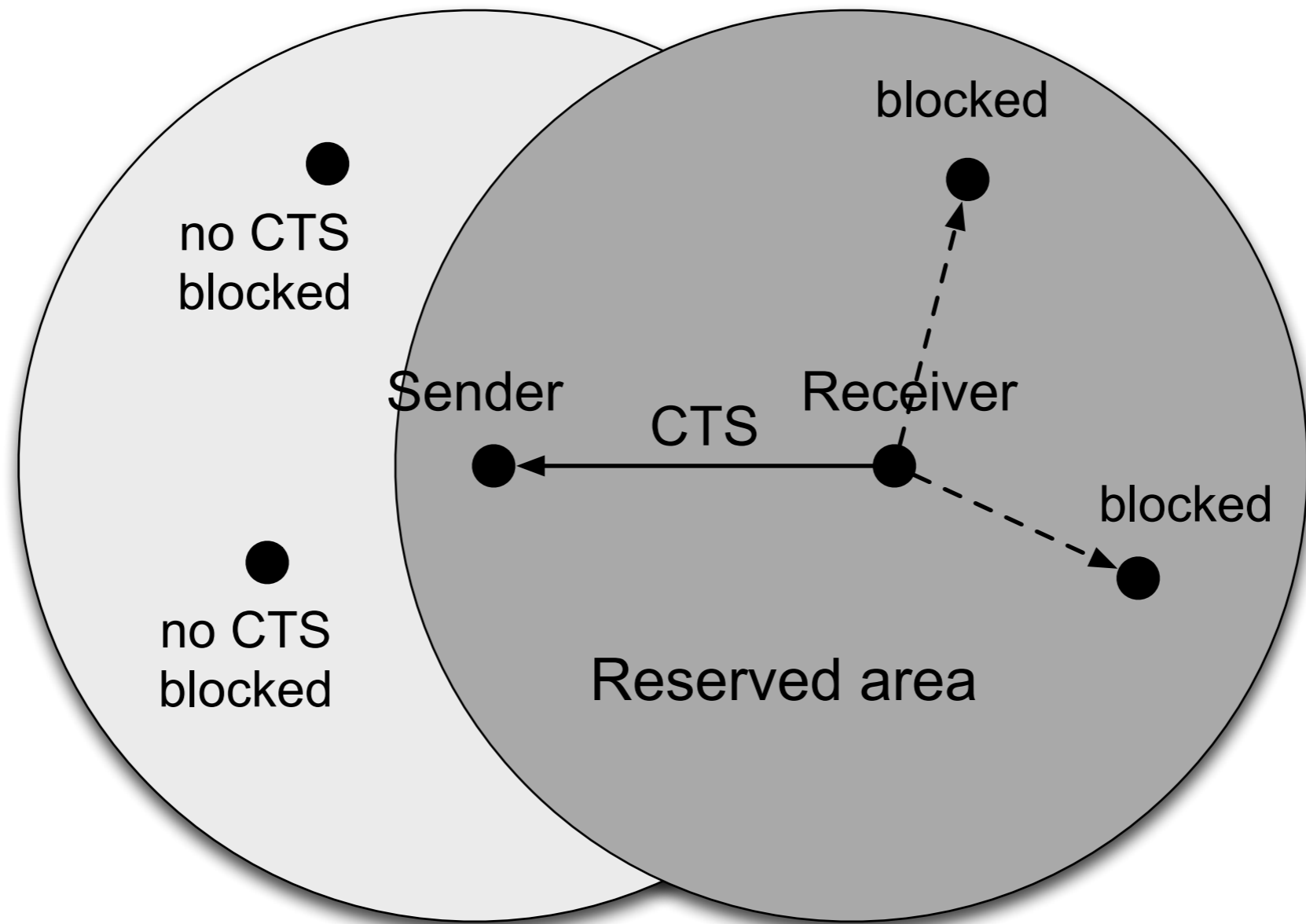
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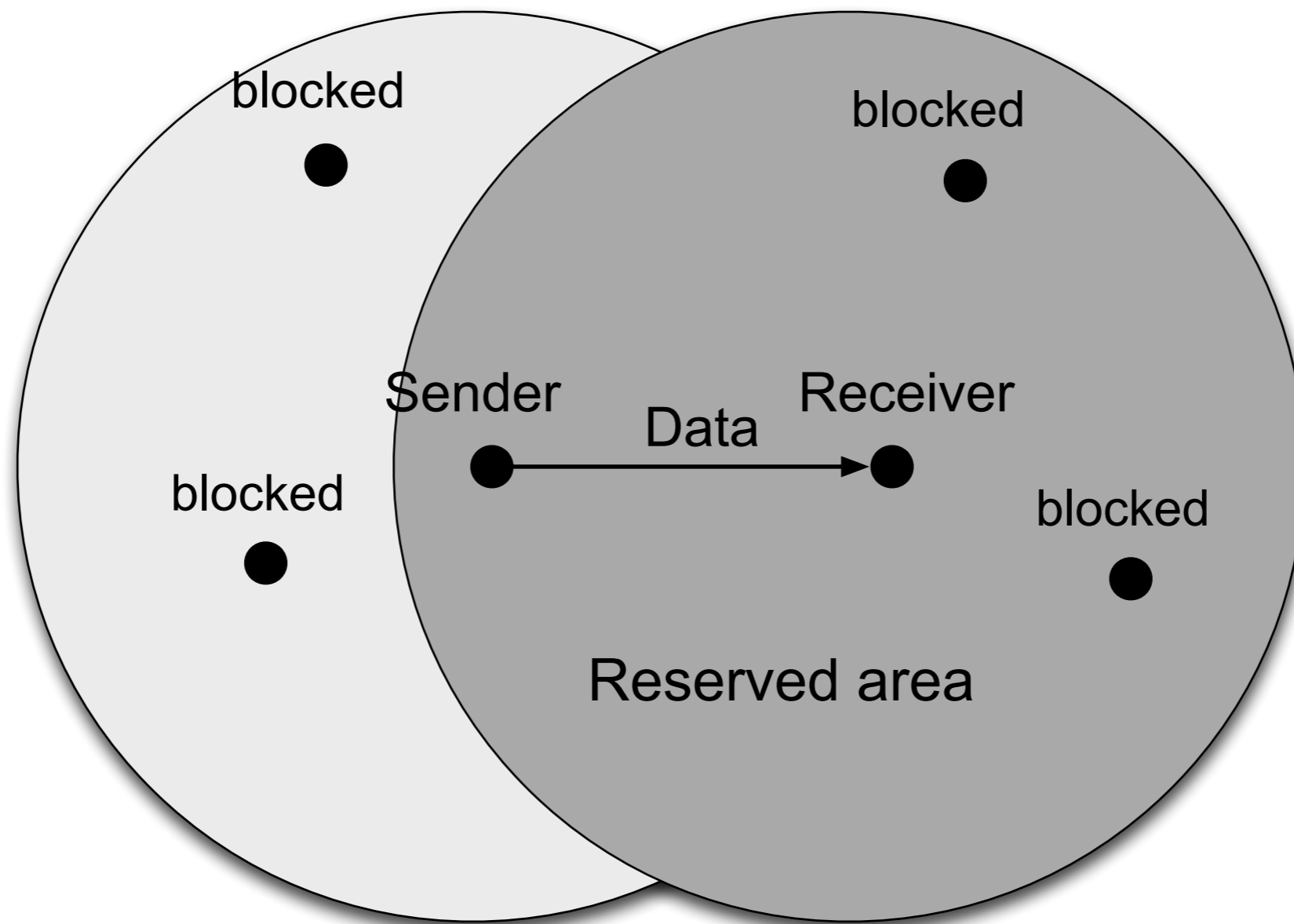
MACA 4er-Handshake RTS



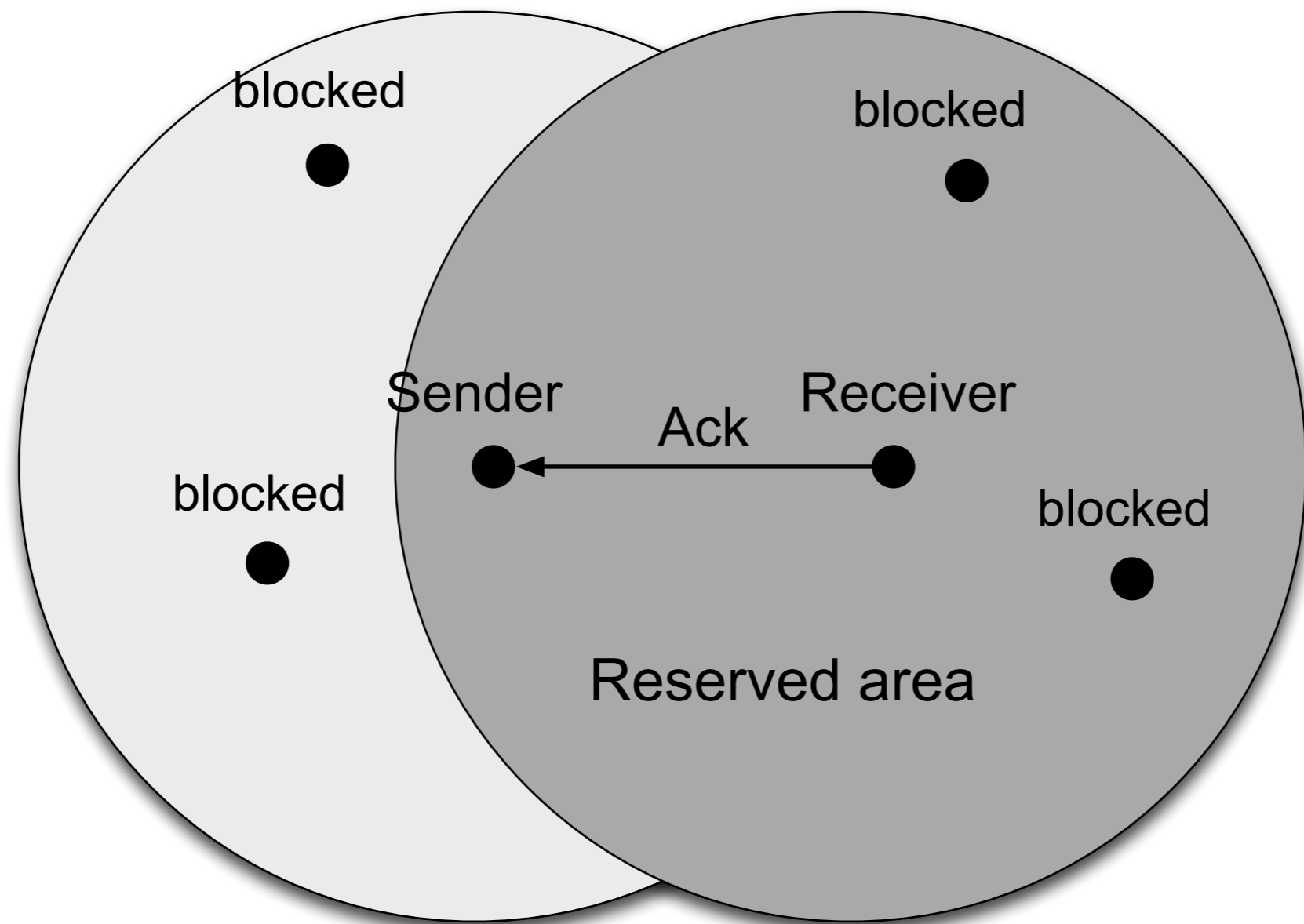
MACAW 4-Handshake CTS



MACAW 4er-Handshake Data



MACAW 4er-Handshake RTS



Acknowledgments

- ▶ **Adding ACKs to MACA**
 - In MACA done by transport layer
- ▶ **leads to drastical improvements of throughput even for moderate error rates**

error rate	throughput	
	RTS-CTS- DATA	RTS-CTS- DATA-ACK
0	40	37
0,001	37	37
0,01	17	36
0,1	2	10

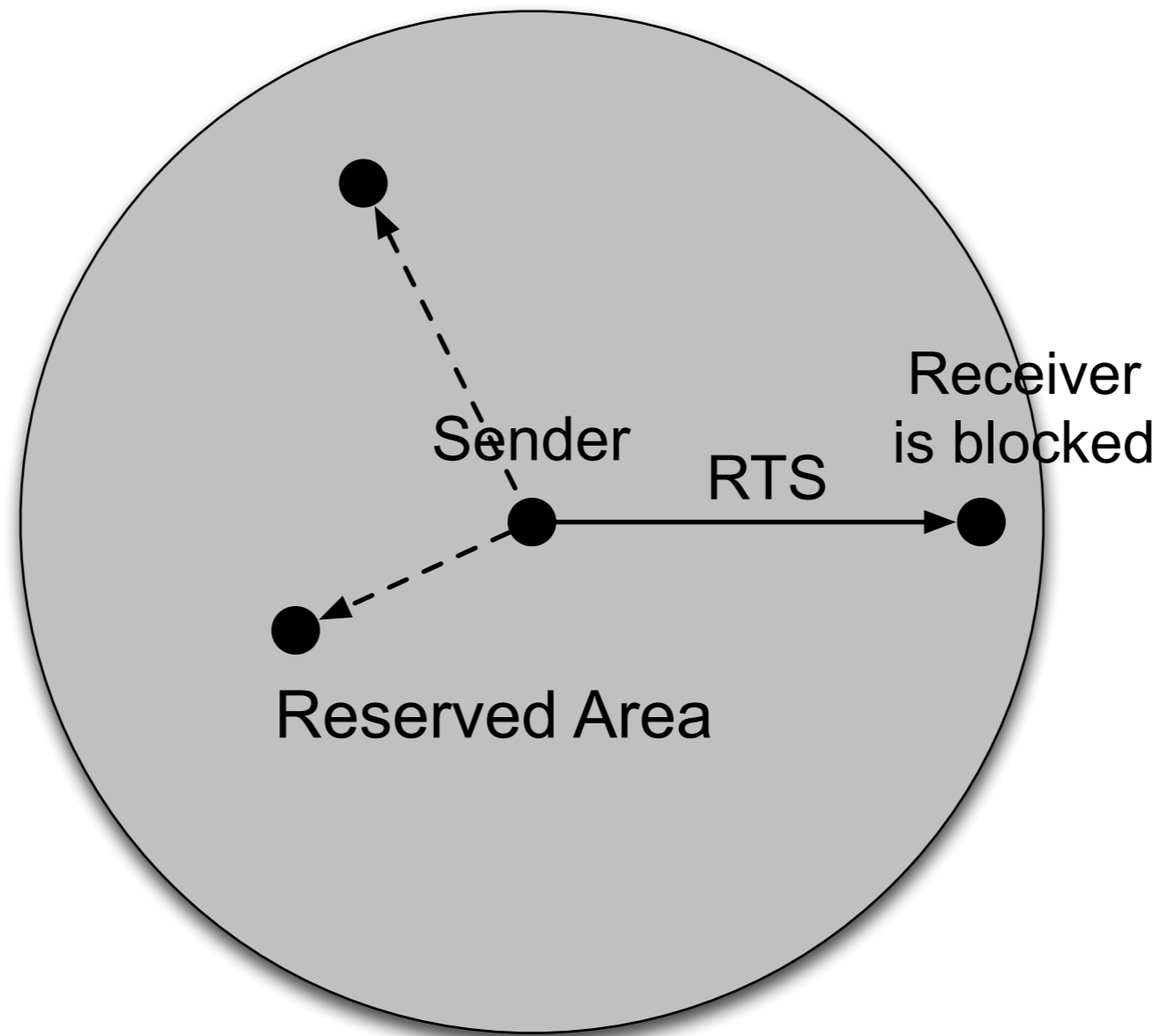
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4 Handshake

► **Worst-Case blockade**

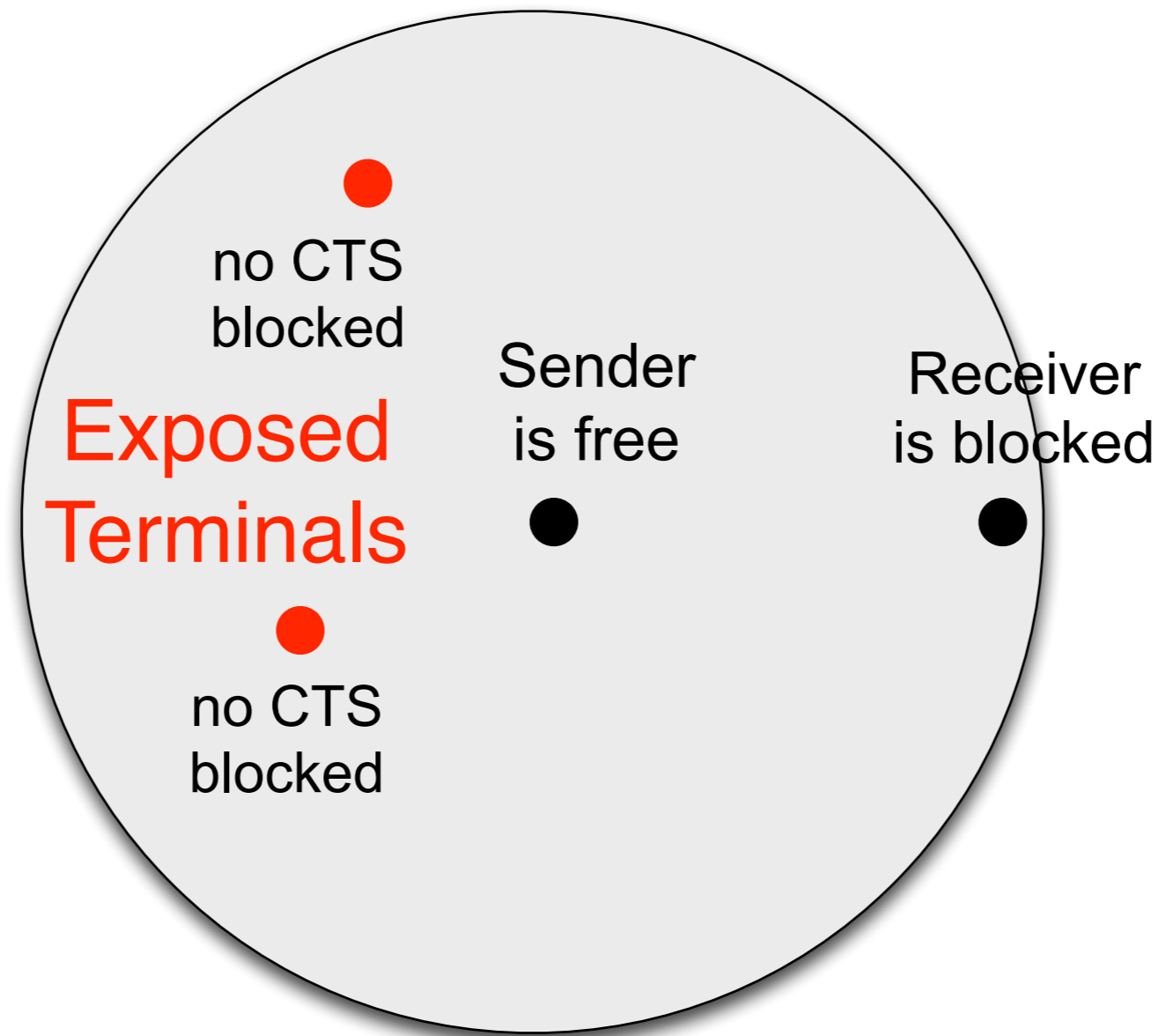
- Sender sends RTS
- Receiver is blocked
- Sender is free
- But the environment of the sender is blocked

MACAW 4-Handshake RTS



MACAW 4-Handshake

CTS is missing



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5 Handshake

- ▶ **4-Handshake increases Exposed Terminal Problem**
 - Overheard RTS blocks nodes
 - even if there is no data transfer
- ▶ **Solution**
 - Exposed Terminals are informed whether data transmission occurs
 - Short message DS (data send)
- ▶ **5 Handshake reduces waiting time for exposed terminals**

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5 Handshake

► **Participants**

- Sender sends RTS
- Receivers answers with CTS
- Sender sends DS (Data Send)
- Sender sends DATA PACKET
- Receiver acknowledges (ACK)

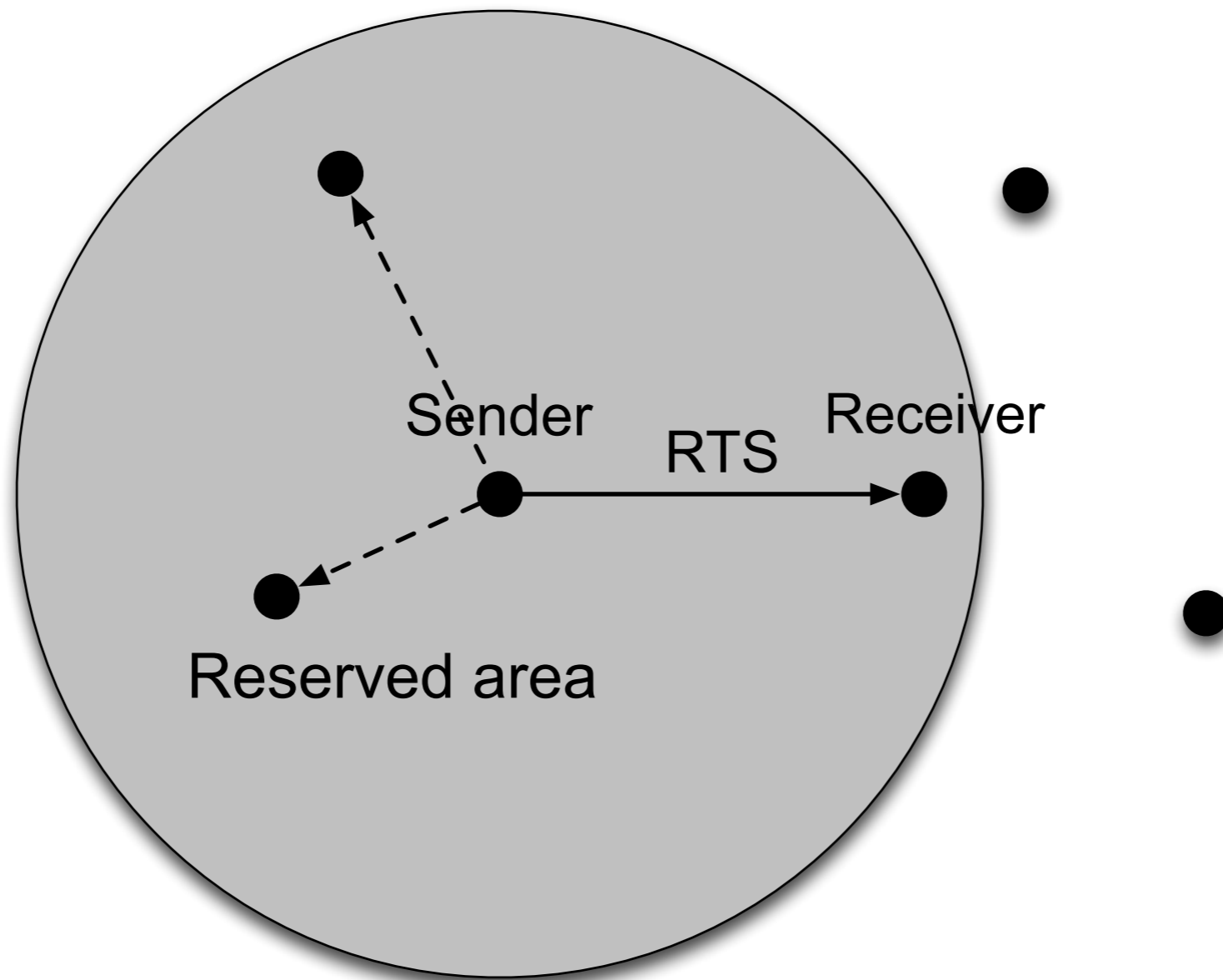
► **RTS and CTS announce the transmission duration**

► **Blocked nodes**

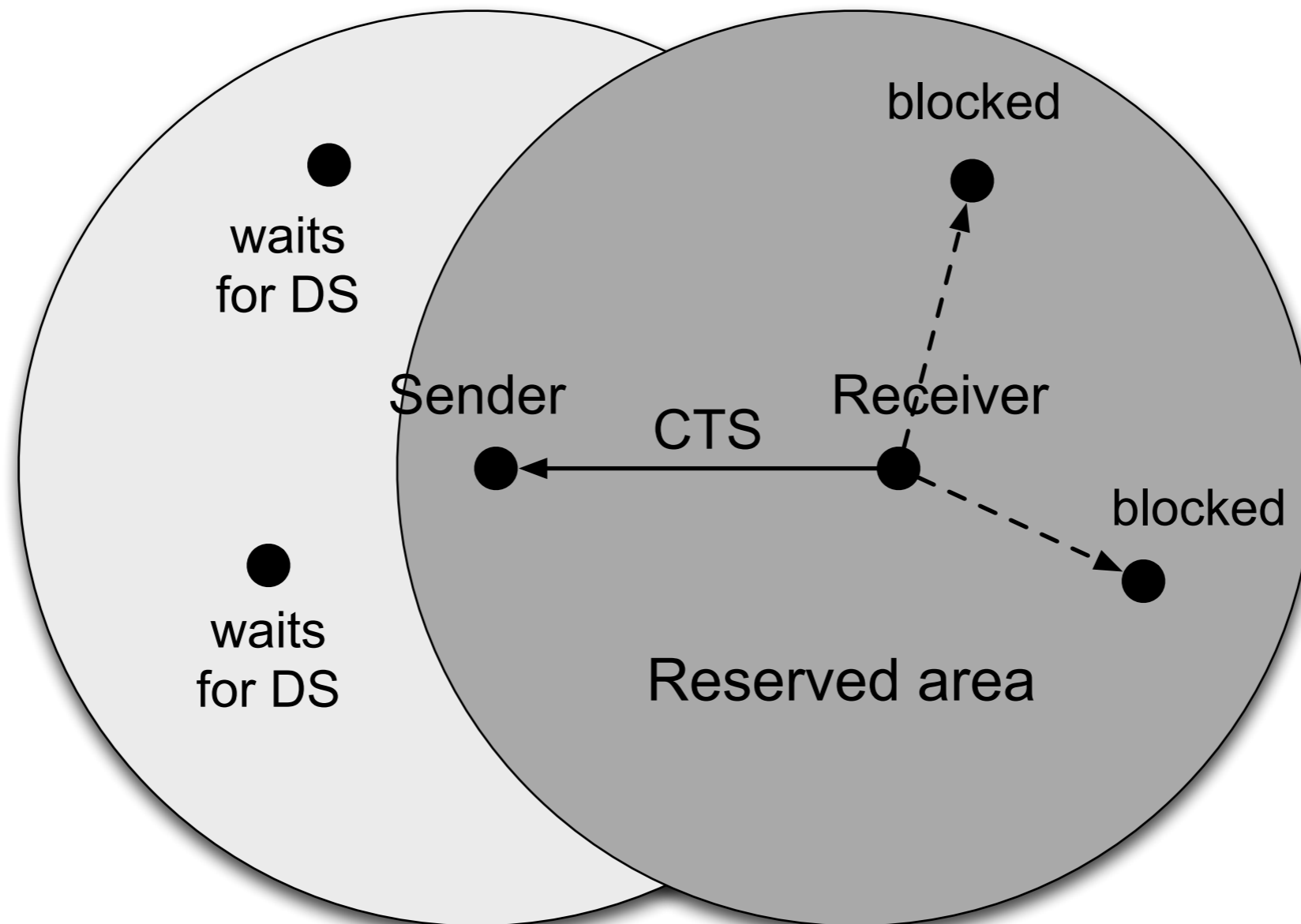
- have received RTS and DS
- have received CTS

► **Small effort decreases the number of exposed terminals**

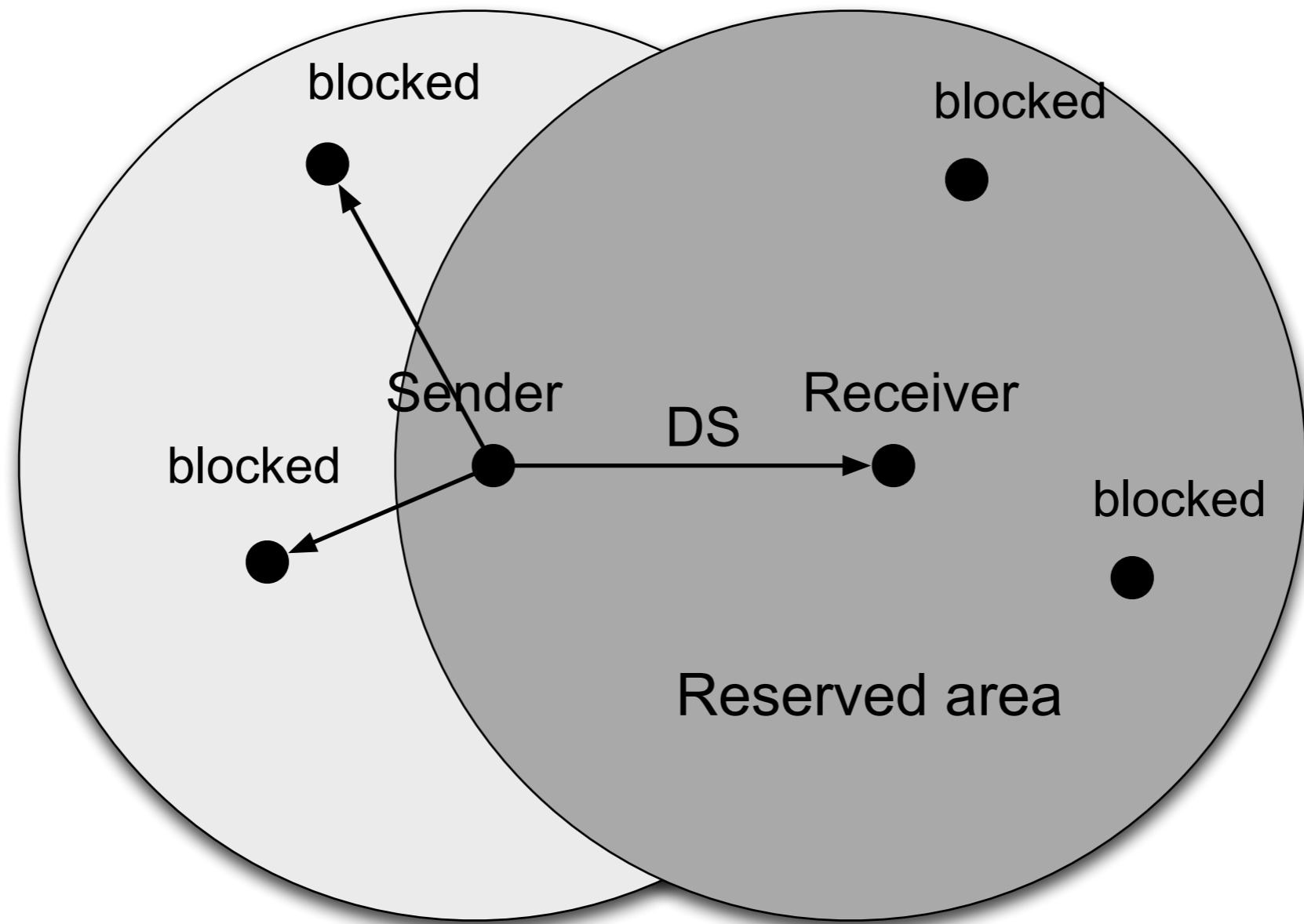
MACAW 5-Handshake RTS



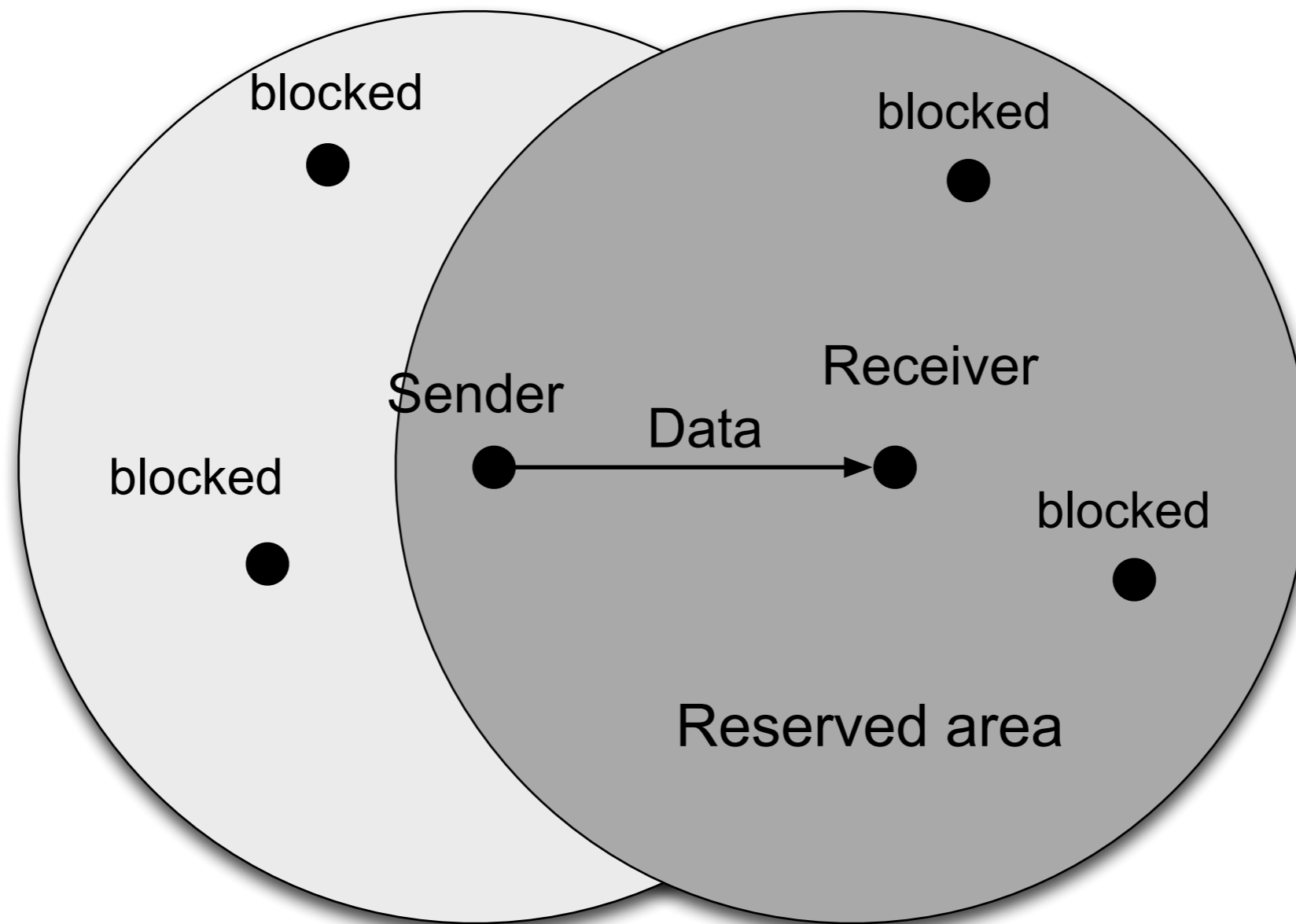
MACAW 5-Handshake CTS



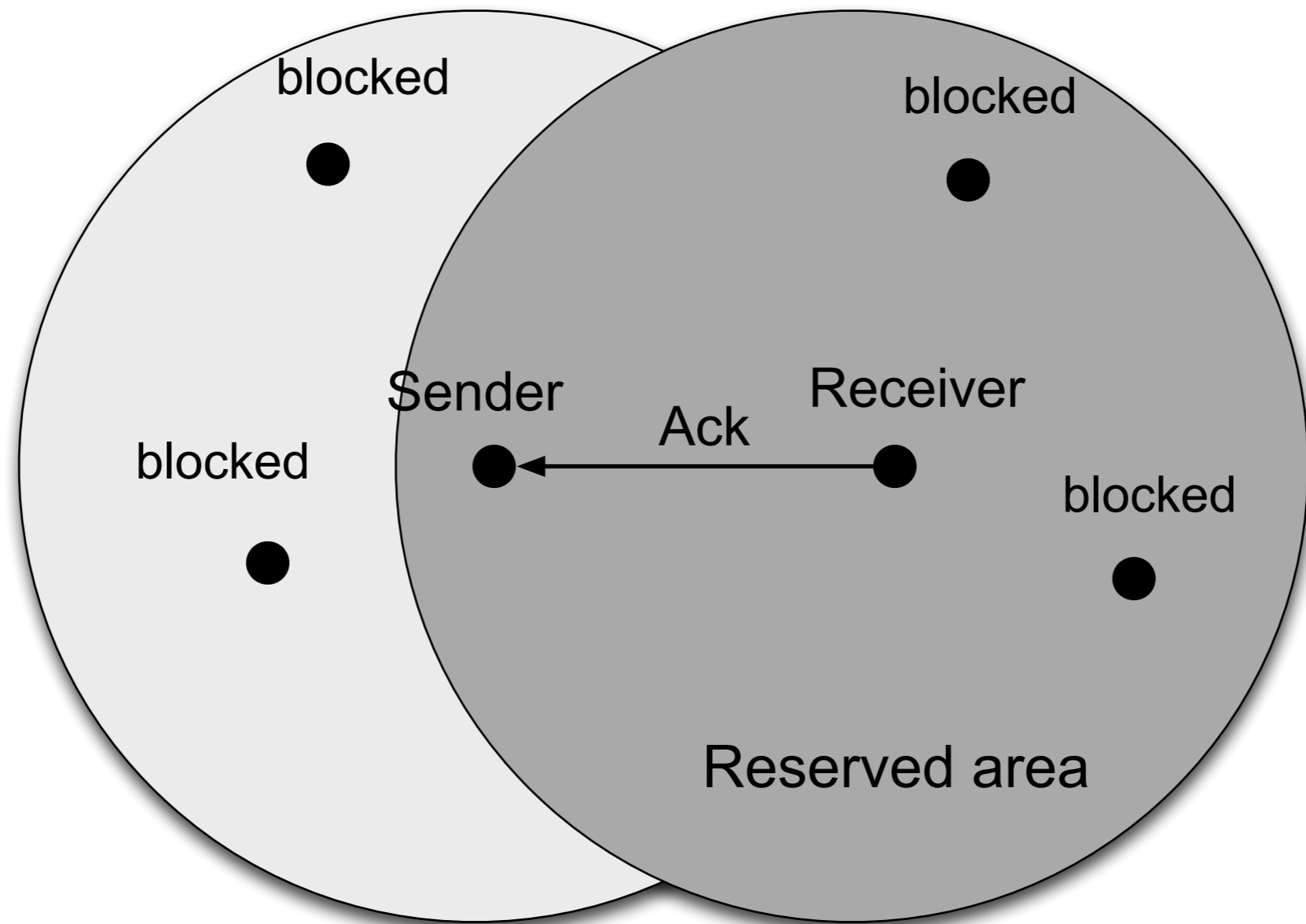
MACAW 5-Handshake DS



MACAW 5-Handshake Data



MACAW 5-Handshake ACK



Unfair Distribution

- ▶ **4 and 5-Handshake create unfair distribution**
 - A has a lot of data for B
 - D has a lot of data for C
 - C receives B and D, but does not receive A
 - B can receive A and C, but does not hear D

- ▶ **A is the first to get the channel**
- ▶ **D sends RTS and is blocked**
 - Backoff of D is doubling
- ▶ **At the next transmission**
 - A has smaller backoff
 - A has higher chance for next channel access



RRTS

► Solution

- C sends RRTS (Request for Request to Send)
 - if ACK has been received
- D sends RTS, etc.

► Why RRTS instead of CTS?

- If neighbors receive CTS, then they are blocked for a long time
- Possibly, D is not available at the moment



Backoff Algorithms

- ▶ **After collision wait random time from $\{1, \dots, \text{Backoff}\}$**
- ▶ **Binary Exponential Backoff (BEB) algorithm**
 - Increase after collision
 - $\text{backoff} = \min\{2 \text{ backoff}, \text{maximal backoff}\}$
 - Else:
 - $\text{backoff} = \text{Minimal Backoff}$
- ▶ **Multiplicative increase, linear decrease (MILD)**
 - Increase:
 - $\text{backoff} = \min\{1,5 \text{ backoff}, \text{maximal backoff}\}$
 - Else:
 - $\text{backoff} = \max\{\text{backoff} - 1, \text{minimal-backoff}\}$

Information Dissemination for Backoff-Algorithm

- ▶ **Backoff parameter are overheard**
 - participants adapt the parameters to the overheard backoff values
 - using MILD
- ▶ **Motivation**
 - if a participant have the same backoff value, then the fairness has been reached



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